Gunnison Copper ISR Draft Permit - Summary of Significant Comments
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Regional Hydrogeology

The hydrogeology discussion should present a water balance for the regional aquifer system, with an estimate of recharge and an estimate of groundwater flow leaving the basin through the two gaps on the east.

Aquifer Properties and Pump Tests

1. Excelsior should consider horizontal anisotropy in its modeling and project design. The effects of not considering this are better considered below in the discussion of modeling.
2. Excelsior should complete at least one longer term pump test using the higher producing wells and monitoring their wells both within the well field, outside the well field, and beneath the well field to provide improved evidence regarding connectivity throughout the aquifers near the project site.
3. The values of storativity vary over six orders of magnitude, which indicates great variability and that no average value should be applied over the entire model domain.
4. Porosity values vary from 0.0133 to 0.0577, which demonstrates significant variability across the site. Graphs of how porosity varies vertically should be presented to illustrate the potential for vertical flow.
5. Figure 1 shows a groundwater divide that would separate its project from the aquifer further south. But if it even exists, it would not prevent contaminants from transporting south through preferential flow paths which could connect areas south and north of the regional divide.
6. The groundwater divide is very flat, and just south of the divide the regional gradient is more south and southeasterly than north of the divide. This would direct contaminants that cross the divide towards Dragoon.

Water Chemistry

1. Due to the importance of understanding the source of petroleum products in the groundwaters on the project site, Excelsior should reconsider the potentiometric surface map to consider whether the water levels all represent the same aquifer level. It is possible that groundwater flows southeast from the mine at certain levels, and therefore the Johnson Camp mine cannot be ruled out as a source of the petroleum products.
2. Hydrocarbons in the groundwater could affect the chemistry of the project. Excelsior must complete a larger survey of the LNAPL contamination and assess whether and how it could affect ISL operations.

Copper Mining Project

1. The site plan (Figure 6) shows the SX-EW plant at the mine site but omits the SX-EW plant at the Johnson Camp mine site.

2. The development blocks (App I, Figure 45) indicate that sections of the well field would be developed such that 5-spot patterns would overlap with adjacent 5-spot patterns which would cause the 4:1 collection to injection well ratio to not hold throughout the project life.
3. There is a possibility that the proposed 0.9 safety factor applied to the maximum injection pressure at each well would be insufficient in some areas. Fracturing could connect previously unconnected fractures and preferential flow zones allowing lixiviant to escape the project area through unmonitored fracture zones.
4. There is no guarantee that the HC wells would intercept flow in each preferential flow Path. The model does not consider the potential for fractures to transmit flow and contaminants from the well field.
5. Excelsior should provide a realistic assessment of attenuation capacity considering the amount of limestone that escaping acid solution would contact.
6. Rather than specifying a number of pore volumes of rinsing, the requirement should be to rinse until a given contaminant concentration is reached.
7. The draft permit should outline a strategy for remediation during the post rinsing period.

Monitoring Wells

1. Even if monitoring wells show a 1% inward gradient, it is possible for fluids to escape hydraulic control through preferential flow pathways.
2. Draft permit, Appendix A, Figures A-7a, A-8, and A-13 through A-16, show the monitoring wells as operated for given time periods. The draft permit does not show the monitoring well layout after year 13 (Figure A-16), which is the end of mining stage 2.
3. The monitoring well scenario described within the draft permit is insufficient to protect offsite resources, including wells near Dragoon, which violates requirements for monitoring well spacing based on an assessment of geology.
4. The gradient measured by the OW wells as designed could meet the standard, but there could be zones within the monitored rock with gradients away from the project. Each productive zone could have its own gradient which could be masked within the OW well, resulting in flow leaving the mine site undetected.
5. Each OW well should be assessed to determine whether there are different productive zones and each zone should be monitored separately, including groundwater level and water quality.
6. HC wells should also be considered as to whether they control some flow zones better than others. The HC wells should have the ability to produce from all productive zones they intersect.
7. The Draft Permit establishes special consideration for three HC wells established on the southern project boundary prior to year 1, but the response is inadequate because the wells would be spaced too widely and would be grossly insufficient to monitor the threat of contaminant escape southward through the NW-SE trending faults that transect the southern boundary.
8. The five POC wells located outside the area of review (AOR) (Figure 7) are grossly insufficient due to preferential flow pathways and because large contaminant plumes could flow between the wells undetected.
9. The number and spacing of POC wells should be determined by modeling of

contaminants being released either within the well field or the ponds accounting for horizontal dispersion.

10. The POC wells downgradient from the well field should monitor different vertical preferential flow paths separately.
11. The UIC permit should require monitoring for contaminant excursions across the southern boundary by considering the following:
    a. The HC wells should be fully installed and active at the beginning of mining. This would create a trough in the water table that would prevent excursions, if the pathways are connected to the regional water table.
    b. HC wells should be installed in fracture zones associated with the faults.
    c. The faults should be more fully monitored, with IMW wells situated along each of them.
    d. POC wells on the south boundary should be about 300 feet south of the HC wells, and be associated with fractures and pathways associated with the faults.
12. EPA should require modeling of leaks from the project, without the HC wells operating, to estimate the likely plume that would develop, including dispersion, to determine the needed POC well spacing. EPA should require POC wells spaced according to the updated plume modeling.
13. Contaminant dispersal through all of the interconnected pathways is highly unlikely because contaminant migration will follow gradients and disperse unequally through a pathway. The permit should require monitoring of pH in addition to SC at the IMWs; that could provide good early warning of a loss of hydraulic control through pathways.
14. The alert limits and aquifer quality limits should be set and enforced for each POC, by screened interval, to set limits and commence mitigation based on preferential pathways.
15. The concentration limits specified for POC wells should account for dilution. This would account for the fact that standards could be exceeded over a portion of the water column but not all of it.
16. The draft permit specifies various actions that will be taken if alert levels are exceeded, but they are in the longer term insufficient. The draft permit must indicate that if exceedances last for more than six months, the facility, or at least the specific section of the well field responsible for the exceedance, must cease operations and commence rinsing.
17. Excelsior proposed the POC wells be monitored for four quarters after rinsing is complete. The length of the monitoring period is insufficient because it is not long enough for contaminants residing within the well field, but not neutralized, to flow from the well field through the POC wells.
18. Monitoring beyond the end of rinsing should continue as long as the estimated travel time for particles from the most distant part of the well field to reach the POC line, plus at least 50% for a safety factor.

Review of Groundwater Modeling Report -Attachment A-2

This section reviews the model and shows that it is not sufficient evidence to show there will be no escape of contaminants.

Model Structure

The model includes neither horizontal anisotropy or an orientation of grids to align with the fracture orientation, which would facilitate simulation of horizontal anisotropy (Attachment A-2, p 18). This is a failure to consider the preferential flow potential parallel to the fracture orientation.

Boundary Conditions

1. The water balance and flow equations require boundary conditions where either the water level, a groundwater flow, or both are specified. There are no flow boundaries on the north, west and south bounds of the model domain which generally coincide with a topographic and expected groundwater divide, as is appropriate.
2. The modeling does not impose any vertical gradient at the model boundary. Because the report does not provide water balance data, it is not possible to assess the reasonableness of the constant head boundaries through which groundwater flow leaves the model domain.

Modeled Material Properties

The fracture intensity was assumed lower away from the ore body, which resulted in a lower simulated conductivity away from the ore body. This has the effect of containing the simulated effects of mining to the project site. The fracture intensity is much higher in the areas with significant faults, as shown on Figure 11.

1. There are at least three major problems with the way the model handles conductivity based on the presentation in Attachment A-2, Table 9:
   a. Permeability, and therefore conductivity, should increase with fracture density, but Attachment A-2, Table 9 has many exceptions which are not logical. Most formations have an example of higher fracture density coinciding with lower conductivity.
   b. With the exception of basin fill, there is no simulated difference among Kx, Ky, and Kz.
   This means the model would treat conductivity in all directions for all bedrock formations equally.
   c. The conductivity values are commonly the same depending on fracture intensity rather
   than formation type. This suggests there have been too few aquifer tests to justify discretizing among so many formation types. It also means there are no differences among geologic formation types.
   d. The text claims the formation outside of the ore body is not mapped with respect to fracture intensity, represented by zone 0 for each formation on the table. The claim is that "fracture intensity appears to be strongest in the area of the ore body", therefore the conductivity outside the ore body is usually lower than within the ore body. However, Excelsior did not sample outside the ore body (Id.), so there are no data or evidence to support this claim.

    e. Attachment A-2, Table 11 purportedly includes calibrated K values, but shows values as high as 65 ft/d, whereas the figures showing calibrated K zones with values (App I, Figures 21-27) do not show any values greater than 10 ft/d. This is a substantial error in the presentation of the model parameters.
2. There is no discussion of vertical circulation as part of the conceptual model, meaning the modelers had no expected natural vertical circulation of groundwater flow. It is likely that the numerical modeling allows an unrealistic amount of water to flow at depth through the domain because of vertical K equaling horizontal K, especially at depths below layer 1.
3. Attachment A-2 does not provide water balance data, either for the entire model or for individual layers, as is customary for the presentation of groundwater model results. This limits the ability of the reviewer to assess how realistic is the simulated groundwater flow.
4. Specific storage was set equal to 0.00001/ft, which ignores the vast variability in values found during the pump tests.

Model Calibration

1. The rapid change in residual across the site indicate the conceptual model for the area is inaccurate. Drawdown at NSH-019 had been predicted to be 4.89 feet but the model simulated just 0.01 feet (Figure 17). This is due to the fracture-dominated flow system and that drawdown depends on the observation well being developed in the same fracture system as the pumping well.
2. These results demonstrate future problems that will occur with the system. Injection of leachate into a fracture zone that does not have a collection well or a control well will allow flow to exit the system.
3. Based on the information regarding calibration of recharge and material properties at the same time in Attachment A-2, the Gunnison model is nonunique. It is accurate only if the recharge estimates are accurate but there are no measurements of recharge.
4. The problems with the model being nonunique are that the parameters values may be grossly wrong. This could affect the predicted results of the project simulations and lead to inappropriate assumptions about the operations of the model, especially on a regional basis.

Model Recommendations

The previous sections provided comments on numerous aspects of the model, but there are two overriding recommendations which would improve the model and improve most of these comments.

1. The model should be improved with a better conceptual flow model, that better accounts for the fracture system near the well field due to the faults. It should better simulate horizontal anisotropy as caused by the fracturing. It should have more layers to better simulate the steps in the observed water table.
2. The conceptual model should also include estimates of discharge from the model domain. These estimates should be targets in the calibration, which would make the model more unique.

Simulation of the ISL System

The simulation of particle capture and release is not an accurate presentation, for the following reasons:

1. Drawdown throughout the mining area caused by pumping only the hydraulic control wells is unrealistic. Without simulating the injection/collection wells, this model does not provide reliable information regarding the effect of the injection/recovery system on local or regional flow paths.
2. Contaminants in the model would be released at the edge of the interior well fields (Figures 19 and 20), but they would not be under pressure as they will be during operations. During operations, the particles would be released at the beginning of a pressurized stream that would cause the particle to move faster than simply being placed at given levels in the aquifer.
3. The model simulates pathways that are at a minimum 50-feet wide (model cell sizes) which means the properties are effectively an average over an area that wide. It completely misses the potential narrow pathways that could preferentially allow particles to exit the system.

Simulation of mining should be improved by doing the following:

1. The actual injection/recovery wells should be simulated, with injection rates depending on the localized conductivity and pressures that would be acceptable for operations.
2. The model should be discretized into much smaller cells at the mine so that injection/recovery can be simulated more accurately. This could include telescoping the regional model into a much more detailed model at the well field.
3. The geology/fracture intensity model should be used at a smaller scale to provide more detail of flow paths through the well field.
4. The POC wells should be redesigned according to results from the modeling. The flow model should be used with MT3DMS to simulate transport from the well field to the POC wells. Assuming sources emanating from various positions through the well field, the model could simulate a plume that POC wells should be positioned to detect.

Clear Creek should provide figures similar to Figure 21 for other time periods and for other model layers. Simply maintaining a drawdown is insufficient; it is necessary to maintain a hydraulic low point wherein no flow from the well field can escape into the regional flow field.